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**Financial Contagion and Capital Asset Pricing in Africa: The Impact
of the 2007-09 and Euro-Zone Crises on Natural Resources Sector
Beta in African Emerging Markets**

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Abstract

This paper contributes to the literature by extending the interpretation of financial contagion beyond that of the market correlation approach popularised by Forbes and Rigobon (2002). Contagion is explored from the perspective of its impact on the conditional sector-risk Beta of the African Emerging Market natural resources sector. A multi-factor CAPM model is developed within a DCC-MGARCH framework to estimate time-varying Beta. We find that this reacts in different ways to different contagion events. It rose by a statistically significant 0.058 (an 8% increase) in response to the euro-zone crisis. However, with the exception of South Africa, the 2007-09 crisis was found to have no significant impact on Beta. We speculate that the differences found can be attributed to the different ways in which individual contagion events impact on individual markets. From this we conclude that ‘one size fits all’ correlations-based contagion analysis can often hide as much as it reveals.

Keywords: Financial Crisis, Contagion, Conditional Beta, African Emerging Markets

JEL Classifications: C58, G01, G12

1. INTRODUCTION, AIMS AND LITERATURE

The global financial crisis of 2007-09 and the more recent Euro-zone crisis have led to the term ‘contagion’ becoming an increasingly important element of the financial lexicon. Forbes and Rigobon (2002) measured this in terms of an increase in correlation and describe it as “a significant increase in cross-market linkages resulting from a shock hitting a country or a group of countries”. In this paper we contend that we should also consider further ways of extending our understanding of contagion given that individual crisis are very much unique in nature.

We contribute to the literature by examining African Emerging Markets (AEM) contagion events in terms of the impact of the 2007-09 and Euro-zone crises on relative sector-risk (sector Beta). We focus on the natural resources sector given that this dominates AEM stock listings. For example, in South Africa, Basic Materials represent over 25% of stocks on the JSE (Mayer, 2013), and resource-driven stocks in Egypt and Morocco form about 38.4% and 15.3% of their respective market capitalisations (Hearn, 2011).

A number of studies have been undertaken of contagion in Africa using the correlation-based approach popularised by King and Wadhvani (1990) and Forbes and Rigobon (2002). For example, Asongu (2011) used it to identify contagion in response to the Kenyan crisis of 2007-08 and Bello and Rodgers (2016) used a dynamic conditional correlation based variant to find evidence of contagion from the 2007-09 global financial crisis to African Frontier markets. Separately, Bello (2014) also found correlation contagion in African emerging markets during this period. A number of alternative methodologies have also been explored in the literature. For example, Aizenman et al. (2016), using an event study, found a distinction between the impact of ‘global crisis news’ and ‘euro crisis news’ on developing African countries. Using quantile regression model along with Coexceedance, Chevapatrakul and Tee (2014) investigated how news events contributed to contagion events on stock market indices during the 2007-09 financial crisis. In a more recent study, Jin and An (2016), employed the volatility impulse response approach (VIRF) and found contagion from the US to BRICS stock markets also during the 2007-09 financial crisis. Other researchers have focused on the importance of contagion channels; for example, Essers (2013) and Allen and Giovannetti (2011). Their studies identified potential channels as: trade, terms of trade, tourism, foreign direct investment (and land acquisition particularly), private capital flows, remittances and international bilateral aid.

In this paper we argue that contagion methodology can be developed further through an examination of the impact of contagion on sector-risk Beta. However, in an AEM context considerable care is required in identifying the form of Capital Asset Pricing Model (CAPM) used given the unique characteristics of these stock markets. Asset-pricing studies have developed enormously following the seminal work of Sharpe (1964) and Lintner (1965). Some of the more important papers include: Merton (1973), Fama and French (1992), Carhart (1997) and Pástor and Stambaugh (2003). Previous studies have focused mainly on developed markets and the emerging markets of Asia and Latin America. Historically, there has been limited research in Africa, however, more recently researchers have begun to turn their attention to these markets; for example, Omran (2007), Hearn and Piesse (2009) and Alagidede (2011). The methodological issues raised in these papers are taken into consideration in the multi-factor CAPM developed for our study. This model is described in Section 3 and results are presented in Section 4. Finally, a discussion is undertaken and conclusions are drawn in Section 5.

2. DATA DESCRIPTION

Identifying the ‘window’ of any contagion event is potentially problematic. This is especially significant for both the 2007-09 and euro-zone crises as both developed over relatively long periods and contained a series of sub-events.

Researchers do, however, have at their disposal, the VIX index in the United States and the VDAX in Germany to help identify which periods produced the greatest ‘shock’ to investors. These two indices are popularly known as ‘fear gauges’ given their forward-looking properties. Both showed a series of spikes associated with key crisis events and we use these to identify periods of contagion (see Figure 1).

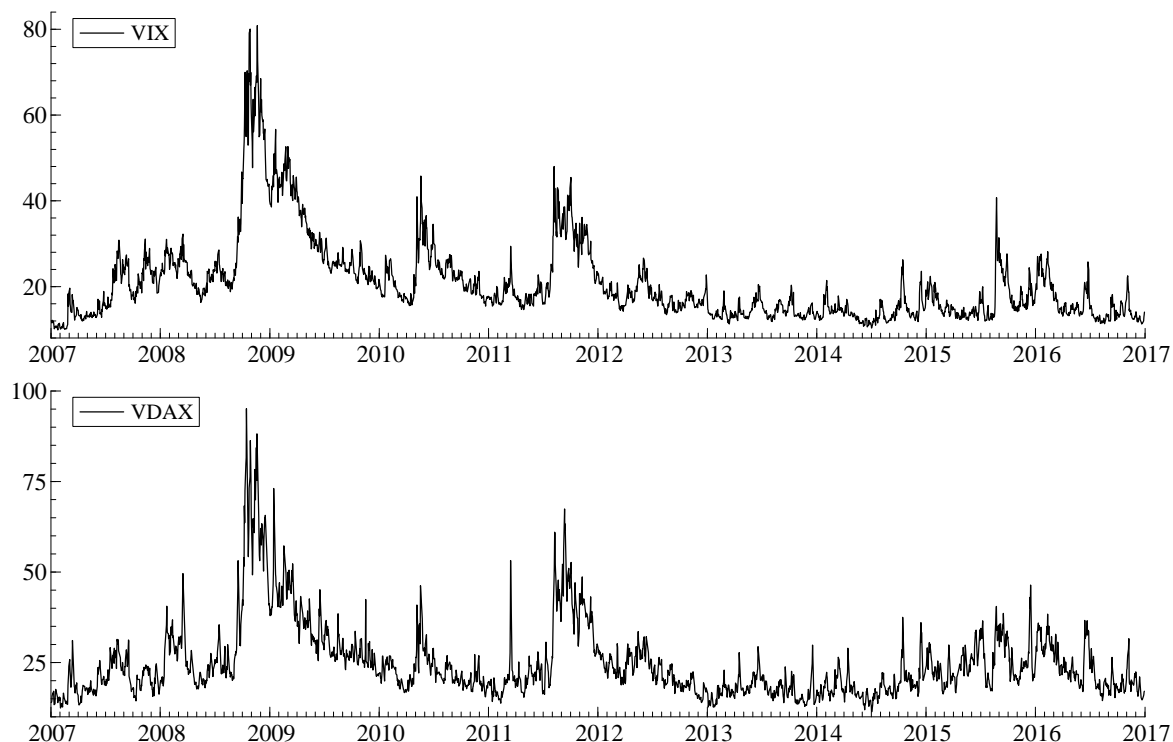


Figure 1: VIX and VDAX Volatility Indices 2007-2016

The first major spike in the VIX occurred in the last quarter of 2008 and was associated with the period that culminated in Lehman Brothers bankruptcy (15th September) but which also included: Federal Government conservatorship of Fannie Mae and Freddie Mac (7th September), the emergency US\$85 billion loan to insurer AIG (17th September) and the sale of Merrill Lynch to Bank of America (14th September). For a list of news events during the crisis, see Chevapatrakul and Tee (2014).

The Lehman bankruptcy was the defining event of the crisis; we therefore use 15th September 2008 to identify the start of the crisis period. The VIX remained high well into 2009, which is an indication that this particular crisis was not the type of short-sharp-shock modelled previously in the contagion literature (For example, Forbes and Rigobon, 2002). A further series of shocks occurred post-Lehman; for example, October 2008 saw the introduction of the US\$700 billion TARP programme and November saw the US government having to rescue Citigroup after speculators drove its share price down 60%.

We also define the end point of the 2007-09 crisis using the VIX. The index started reverting back to its (2000-2010) average by early October 2009. This gives an indication that market

expectations were that the crisis was drawing to a close. On this basis, the *contagion event* is identified in this study as 15th September 2008 to 15th October 2009.

The first significant developments in the euro-zone crisis occurred after our defined end-point of the 2007-09 global crisis. A Eurostat report dated 08/01/2010 identified irregularities in the reporting of the Greek deficit. The crisis gradually escalated, and by May 2010 the Eurozone countries agreed to provide a safety net of 30 billion euros for Greece. A subsequent 78 billion euro bailout to Ireland was agreed in November 2010 as was a further bailout of Portugal in May 2011.

The initial impact of the crisis appeared to have little impact outside of Europe and is therefore unlikely to have had any influence on African markets. However, this situation appeared to change from June 2011 when both the VDAX and VIX started to increase sharply. In the US, the VIX started to spike in June 2011 and peaked by the end of August at 43 (the 10 year Jan 2007-Dec 2016 average was 10.62) before reverting back towards to the 10-year average by the end of May 2012.

In Europe, the VDAX also started to spike in June 2011 reaching a peak by the end of August and, and after a second minor spike in April 2012, it returned closer to its 10-year mean (estimated Jan 2007-Dec 2016) by September 2012. We see these spikes in the fear gauge as being associated with a deepening of the euro-crisis. For example, on 25th May 2011 the IMF threatened not to allow a tranche of aid from the Greek rescue package to be released and in early July Portugal's debt rating was downgraded by Moody's and around the same time Italy was also forced to introduce a severe austerity package. The crisis progressively worsened during the summer and by 21st July the Euro Area Heads of State EU institutions introduced a new package of measures designed to 'prevent contagion'. However, the crisis deepened and a series of events culminated in the VDAX and VIX both spiking to high points by the end of August 2011. The VDAX had a further minor spike in April 2012 but started to revert back towards its 10-year mean in the following months.

We argue that the simultaneous movement in both the volatility indices suggests that euro-zone contagion to outside of Europe started to occur in the early summer of 2011. We identify the downgrading of the Greek credit rating on the 25th July (25/07/2011) as our contagion starting point and define the event ending point as 25/05/2012 when both 'gauges of fear' showed signs of reverting back to their means.

2.1 Data Sources and Descriptive Statistics

The study is based on weekly logarithmic returns of AEM companies that run from January 2004 to December 2015. Data is from local stock markets and is sourced from the Thomson Reuters Eikon. The definition for AEM is taken from the classifications used for the FTSE quality of market criteria (AFRICA) as at March 2014 (FTSE, 2014). This identified South Africa as an advanced emerging market and both Egypt and Morocco as emerging. Given the distinction made between South Africa and the other two, and in order to aid the robustness of our analysis, we run our analysis on three different datasets: African Emerging Markets, African Emerging Markets Excluding South Africa and South Africa alone.

A series of three indices were developed for the three categories by aggregating the companies from their respective basic materials indices; South African (.JBASM), Egypt, (.TRXFLDEGPMAT) and Morocco (.TRXFLDMAPMAT). Survivorship is an important issue amongst African listed companies with a significant number of companies entering and exiting their respective indices over the period of our data. The indices developed were corrected for survivorship bias by applying the CRSP (Center for Research in Security Prices) methodology procedures developed by Carhart (1995). The weekly returns of the aggregated indices are shown in Figure 2.

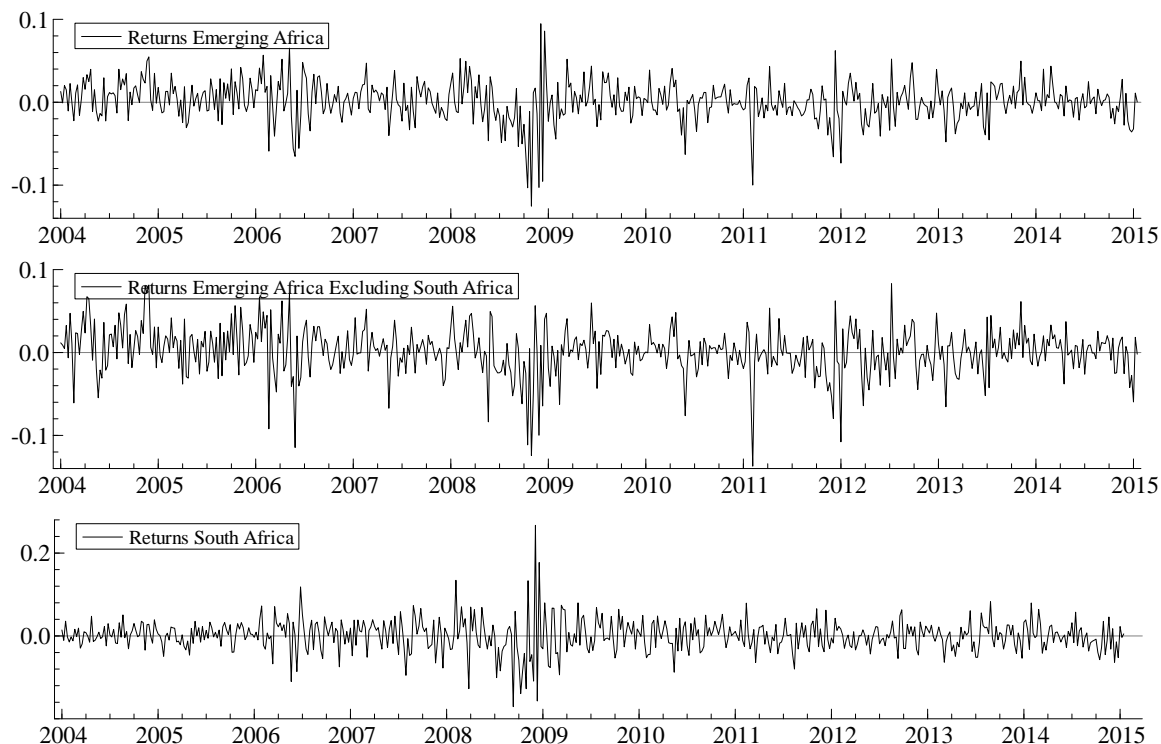


Figure 2: Weekly Returns, January 2004-December 2015, for Respective Natural Resource Sector Portfolios

It can be noted in Figure 2 that there was considerable volatility in returns in all the series towards the end of the 2007-09 financial crisis. There also appears to have been some volatility around the period of the Euro-zone crisis in the AEM and AEM excluding South Africa series. What is possibly a little surprising is that the South African index does not appear to have been impacted more by the Euro-zone crisis.

3. METHODOLOGY

We estimate time-varying Beta parameters¹ using a multi-factor CAPM in association with DCC-MGARCH modelling procedures. The multi-factor CAPM pays particular attention to the specific factors which affect capital asset returns in Africa.

The model is based on, and extends from an African perspective, the Carhart (1997) revision of Fama and French (1992). Survivorship-adjusted returns for the portfolio of natural resource

¹ This and subsequent references to Beta within the text refer to the natural resources sector risk in African Emerging Markets.

sector stocks, net of risk free returns, $(R_{it} - R_{ft})$ are modelled as a function of: Market risk $(R_{Mt} - R_{ft})$, Size risk (SMB), Value risk (HML) and Momentum risk (UMB). To this, in order to take into consideration Africa-specific-factors, we add Liquidity risk (IMV) and also higher-order moment risk effects relating to skewness (S) and kurtosis (K). The construction of the liquidity risk parameter is based on Lesmond (2005) with the bid-ask spread estimate following Jain (2002). The construction of the skewness and kurtosis parameters follow Hwang and Satchell (1999) and Chiao et al. (2003) respectively.

$$R_{it} - R_{ft} = \alpha_i + \beta_{iM}(R_{Mt} - R_{ft}) + \beta_{iS}SMB_t + \beta_{iH}HML_t + \beta_{iM}UMD_t + \beta_{iP}IMV_t + \beta_{iE}S_t + \beta_{iK}K_t + \varepsilon_{it} \quad [1]$$

By taking this approach we are able to introduce significantly more control variables than most previous studies of contagion in Africa. For example, Giovannetti and Velucchi (2013), who only proxy volatility effects through the use of squared returns.

The DCC-MGARCH model we apply is a variant of the original DCC multivariate GARCH model (Engle, 2002). Three sets of mean equations are run in respect to: AEM, AEM excluding South Africa and South African portfolios. These take the form:

$$r_{it} = \alpha_i + \beta_{iS}SMB_t + \beta_{iH}HML_t + \beta_{iM}UMD_t + \beta_{iP}IMV_t + \beta_{iE}S_t + \beta_{iK}K_t + \varepsilon_{it} \quad [2]$$

$$r_{jt} = \alpha_j + \beta_{jS}SMB_t + \beta_{jH}HML_t + \beta_{jM}UMD_t + \beta_{jP}IMV_t + \beta_{jE}S_t + \beta_{jK}K_t + \varepsilon_{jt} \quad [3]$$

where: i represents the asset portfolio (of natural resource sector stocks), j the associated market portfolio, r_{it} the risk-free adjusted return on the asset portfolio and r_{jt} the risk-free adjusted return on the market portfolio. $\beta_{iS}, \beta_{iH}, \beta_{iM}, \beta_{iP}, \beta_{iE}$ and β_{iK} are factor loadings on the Size, Book-to-market Value, Momentum, Liquidity, Skewness and Kurtosis factors, respectively. $\beta_{jS}, \beta_{jH}, \beta_{jM}, \beta_{jP}, \beta_{jE}$ and β_{jK} are factor loadings for the variables in respect of the market j . Q-statistic tests were undertaken to confirm the absence of any autocorrelation in the residual terms. The results from the mean equations are presented in Appendix A.

A number of different functional forms for the volatility and correlation equations were tested in respect to both DCC and asymmetric DCC (ADCC) models (DCC GARCH (1,1), DCC GARCH (2,1), DCC GJR- GARCH (1,1), DCC GJR-GARCH (2,1), ADCC GARCH (1,1),

ADCC GARCH (2,1), ADCC GJR-GARCH (1,1) and ADCC GJR-GARCH (2,1)). ADCC results were found to be inferior to the standard DCC model. The most efficient volatility equations were chosen, subject to the squared residuals showing an absence of autocorrelation (Q-statistic tests). These were identified using information criteria (Akaike, Shibata, Schwarz and Hannan-Quinn)². We expected to see evidence of asymmetric responses to positive and negative returns volatility and this expectation was partially reflected in the functional forms identified; GJR-GARCH³(1,1) was the preferred model for the AEM and South Africa portfolios whilst GARCH(1,1) was the preferred model for AEM excluding South Africa portfolio. The respective variance equations are specified as follows:

$$\sigma_{kt}^2 = \omega_k + \alpha_k \varepsilon_{kt-1}^2 + \beta_k \sigma_{it-1}^2 + \gamma_k S_{t-1}^- \varepsilon_{kt-1}^2 \quad [4]$$

$$\sigma_{kt}^2 = \omega_k + \alpha_k \varepsilon_{kt-1}^2 + \beta_k \sigma_{kt-1}^2 \quad [5]$$

Where: k takes on both the values i and j for the variance equations for the portfolio and the market respectively, S_{t-1}^- is a dummy variable that takes on a value of 1 when ε_{t-1} is negative and otherwise 0. The results are presented in Appendix. They identify that the autoregressive volatility parameter (β) is highly significant in all models and the asymmetric volatility effect (γ) also shows evidence of significance for the AEM and South Africa portfolios. There was, however, only limited evidence of ARCH effects (α); only the AEM excluding South Africa portfolio showed significance in this respect.

The standard focus of the DCC-MGARCH model is to estimate the conditional correlation. The model can be defined as:

$$H_t = D_t^{1/2} R_t D_t^{1/2} \quad [6]$$

$$D_t = \text{diag}(\sigma_{1t}^2 \cdots \sigma_{Nt}^2) \quad [7]$$

$$R_t = \text{diag}(q_{11t}^{-1/2} \cdots q_{NNt}^{-1/2}) Q_t \text{diag}(q_{11t}^{-1/2} \cdots q_{NNt}^{-1/2}) \quad [8]$$

$$Q_t = (1 - \eta - \theta) \bar{Q} + \eta u_{t-1} u'_{t-1} + \theta Q_{t-1} \quad [9]$$

² Akaike and Hannan-Quinn criteria; see Burnham and Anderson (2004), Shibata criterion; see Shibata (1976), Schwarz criterion; see Cavanaugh and Neath (1999).

³ Glosten, Jagannathan and Runkle, (1993).

where: u_t represents the vector of standardised residuals by their conditional standard deviation with elements $u_{it} = \varepsilon_{it}/\sigma_{it}$, \bar{Q} the unconditional covariance matrix of u_t ; η and θ are nonnegative scalars satisfying the constraint $\eta + \theta < 1$ (which ensures models mean-revert), R_t the conditional correlation matrix of ε_t and H_t the conditional covariance matrix of ε_t .

The asymmetric DCC model proposed by Cappiello et al. (2006) accounts for the asymmetries in the correlation dynamics.

However, it is a fairly simple process to derive estimates of the conditional Beta from the covariance matrix. The conditional beta is estimated as:

$$\beta_{iMt} = \frac{\text{conditional covariance}_{ijt}}{\text{conditional variance}_{jt}} = \frac{\sigma_{ijt}}{\sigma_{jt}^2} \quad [10]$$

where: i = the asset portfolio and j = the market portfolio.

Multivariate Student-t distributed errors (Bollerslev, 1987) were applied in the results presented in Appendix A. As expected, the unconditional correlation between the portfolio and market (ρ) is highly significant in each model. The autoregressive vector (θ) is also highly significant in each model which indicates that the conditional Beta will be strongly autoregressive. Although the η term shows much lower levels of significance in each case, the estimated parameters are large enough to ensure that the conditional Betas will exhibit reasonable levels of variation over time and therefore should be able to identify the impact of any contagion events.

3.1 Testing for Contagion

We test for contagion by regressing the time-varying Beta values against dummy variables representing the 2007-09 and euro-zone crises. To increase the robustness of the analysis, an AR(1) term is added to the equation and we also test the crises on both an individual basis and a joint basis (Equations 11 and 12).

Using a dummy variable based test for a time-series regression without an AR term would be likely to introduce an autocorrelation problem and the resulting regression would also likely exhibit omitted variable bias. As well as controlling for the autocorrelation problem,

Wooldridge (2009) suggests that the AR(1) term is a good proxy for omitted variables. We also note the use of this approach by other researchers; for example, Moore and Wang (2014).

$$CB_{ij,t} = \gamma_1 + \gamma_2 CB_{ij,t-1} + \gamma_3 2008_09_t + \gamma_4 EuroZone_t + \varepsilon_{ij,t} \quad [11]$$

$$CB_{ij,t} = \gamma_1 + \gamma_2 CB_{ij,t-1} + \gamma_3 CombinedCrises_t + \varepsilon_{ij,t} \quad [12]$$

where: $CB_{ij,t}$ is the conditional beta at time t , for the asset portfolio (i) relative to the market portfolio (j) and the other variables represent crises dummies. The hypothesis tested for contagion is that of the presence of a statistically significant dummy variable parameter. Forbes and Rigobon (2002: 2239) define contagion as ‘‘parameter exhibiting statistical significance at the 5% level using a one-tail test’’. However, unlike Forbes and Rigobon, we have no prior expectation as to the sign of this parameter as this will depend on perceived changes in the risk of the asset class relative to the market. We therefore adapt their test by defining contagion as statistical significance at the 10% level using a two-tail test.

4. RESULTS

The weekly time-varying conditional Beta coefficients for each of the three portfolios are shown graphically in Figure 3. These can also be compared against their respective unconditional Betas of: 0.739, 0.571 and 0.762 shown in Table 1. The unconditional Betas indicate that risk levels in the natural resources sector are well below the market average. However, this average hides a considerable amount of time-related volatility. For example, in AEM the conditional Beta ranges from 0.28 to 1.79, i.e., between 0.28 of the average market risk to 1.79 times the average market risk.

What is also apparent from the charts is that the relative risk of the natural resources sector in South Africa showed a much greater response to the 2007-09 global crisis than it did to the Euro-zone crisis. Conversely, the opposite appears to be the case for other African Emerging Markets, where the response to the Euro-zone crisis appears to be substantially greater. The statistical significance of these differences is tested through the dummy variable regression and the results are presented in Table 1.

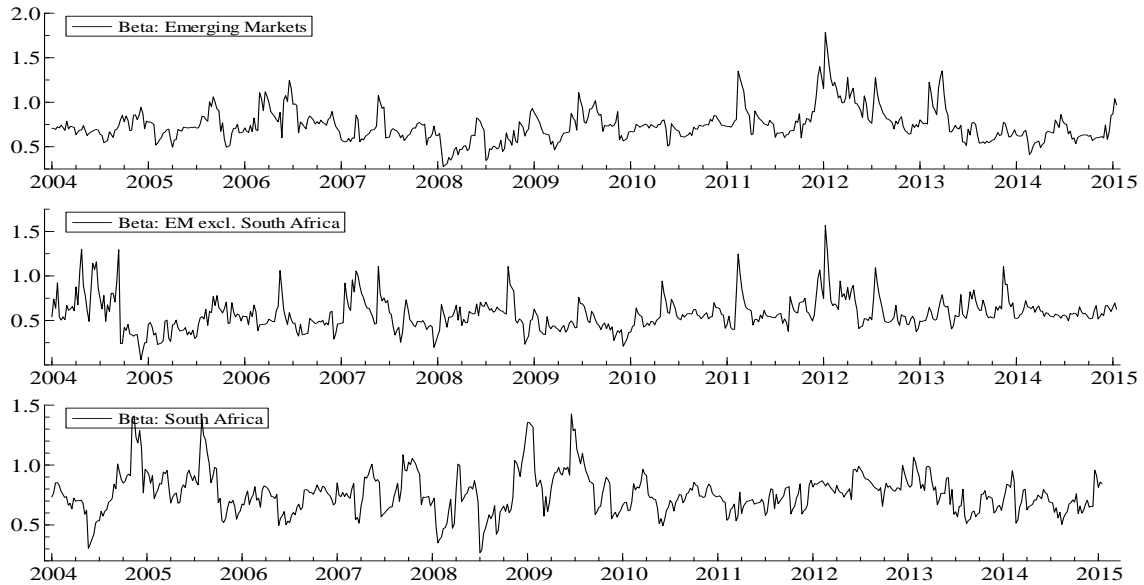


Figure 3: Time-Varying Conditional Beta Estimates 2004-2015: Weekly Data

Table 1: Beta Contagion Tests for 2007-09 and the Euro-Zone Crises

	Individual Crisis Event Dummy Variables			Joint Crises Event Dummy Variable		
	Emerging African markets	Emerging African markets excluding South Africa	South African market	Emerging African markets	Emerging African markets excluding South Africa	South African market
Constant	0.129	0.168	0.168	0.116	0.157***	0.127
Conditional Beta $t-1$	0.819	0.702	0.702	0.837	0.722***	0.829
Dummy: 2007-09 Crisis	0.005	-0.021	0.034**			
Dummy: Euro-Zone Crisis	0.058**	0.045*	0.045			
Dummy: Combined Crisis				0.026**	0.007	0.022**
Contagion	Yes	Yes	Yes	Yes	No	Yes
Unconditional Beta	0.739	0.571	0.762	0.739	0.571	0.762
Adj.R ²	0.727	0.529	0.708	0.724	0.524	0.707

*Significant at 10%, **Significant at 5%, ***Significant at 1%. HCSE robust standard errors are applied (White, 1980). Contagion is defined as statistical significance at 10% level using a two-tail test. Sample size: 573 weekly observations.

The observations made through a visual examination of Figure 3 appear to be confirmed in the statistical tests undertaken in Table 1. If the AEM portfolio is considered first, it can be identified that euro-zone crisis increased the conditional Beta by a statistically significant 0.058 (from 0.739). This represents an increase of approximately 8%. The increase in the AEM excluding SA was 0.045, also approximately 8%. In neither of these two cases did the 2008-09 crisis have a statistically significant impact on the conditional Beta; this seems to tally with the visual inspection of Figure 3.

The impact of the two crises on South Africa is quite different. Only the 2007-09 crisis showed statistical significance; with the Beta increasing over this period by 0.034 or approximately 6%. We will explore the issue of the difference between these two sets of findings in more detail in the discussion.

The model which combines the two crises provides supporting evidence that the contagion events increased Beta. The increases in the statistically significant models range between 0.022-0.026 which in percentage terms range between 2.9%-3.5%.

We would contend that these series of results contribute to the literature by providing strong evidence that individual contagion events are unique in terms of their impact on the risk profile of Emerging Africa's most important market sector.

5. DISCUSSION AND CONCLUSIONS

We argue that market expectations are that a global economic-crisis-induced-recession would lead to an increase in the relative riskiness of industrial-processes related commodity producing companies. They are normally characterised by markets as being cyclical stocks. This is because demand for their types of products is very sensitive to economic downturns. Our expectation therefore is that the sector Beta would rise in response to a contagion event; this is generally what our results suggest.

Our results indicate that the relative risk profile of natural resource AEM stocks reacted very differently to the two separate contagion events. They also show that there were significantly different responses within the AEM group. We speculate that these differences may be due to: (i) differences between the contagion events, (ii) differences in the extent of integration with

the global financial system within the AEM group and (iii) changes in market perceptions of risk in the natural resources sector between the contagion events.

The 2007-09 crisis was seen by many at the time as representing a systemic risk; as was argued by Acharya et al. (2017). We would also argue that it was of a much greater systemic threat than the subsequent events in the Euro-zone. The greater volatility experienced in the South African markets natural resources sector (see sub-charts 2 and 3 in Figure 2) and the greater impact on its conditional Beta was possibly a reflection of South Africa's greater level of integration with the world economy. It was noted previously, the FTSE quality market criteria describe South Africa as the only African 'advanced' emerging market and Agyei-Ampomah (2011) found that, with the exception of South Africa, levels of global integration on the continent are relatively low. The greater volatility and the bigger impact on Beta experienced by South African markets at the time may be a reflection of the Collins and Biekpe (2003) argument that countries with higher levels of global integration are more exposed to global crises than countries that are less financially integrated. They suggest the latter will be relatively immune to contagion. This may possibly explain why in the rest of AEM, the 2008-09 crisis did not have a statistically significant impact. The negative sign might possibly reflect the fact that as the crisis originated in the financial sector of Western markets, any contagion which did occur in AEM excluding South Africa, was centred on the financial sectors of these markets rather than their natural resources sectors

It is more difficult to explain why contagion from the euro-zone crisis focused on non-South Africa AEMs. We do note, however, that although the impact on South Africa is not statistically significant, the sign is positive as expected. We speculate that the lack of significance could possibly be a reflection of the diverse and heterogeneous nature of the natural resource sector in this country, and that this may have led to an increase in the standard error of the parameter. For example, the perceived riskiness of precious metal producers in the sector may have actually fallen as gold and platinum act as safe haven assets in times of crisis.

We argue that changing market perceptions as to the riskiness of natural resource stocks around the time of the euro-zone crisis may explain why the impact of the crisis on Beta was statistically significant for non-South Africa AEMs. An examination of international markets around this time reveals that these stocks began to be seen as being increasingly risky *relative* to the rest of the market during this period; this is reflected in major falls in both absolute and

relative terms of the share prices of major international resource-based companies from 2011-2016⁴.

We argue that main contribution of this paper is that it shows that researchers should look beyond market correlation analysis when they examine contagion events. Identifying that contagion increases the correlation between markets will be of interest to international investors in emerging markets but it is not particularly insightful for their stock picking decisions. We argue that studies which identify the impact of contagion events on the relative risk profiles of specific sectors are likely to be of greater interest to investors in Emerging Markets. This study shows that the ‘one size fits all’ correlations-based contagion analysis popularised by Forbes and Rigobon (2002) can often hide as much as it reveals.

⁴ The MSCI World Metals and Mining Index fell significantly from Q2 2011 to Q1 2016 (covering the period we define as the euro-zone crisis). In contrast, the MSCI World index rose from Q2 2009 to Q2 2015. This indicates that the resources sector significantly underperformed in relation to the general market during the euro-zone crisis. Source: Thomson Reuters Eikon.

REFERENCES

- Acharya, V. V., Pedersen, L. H., Philippon, T. and Richardson, M. (2017): "Measuring systemic risk" *Review of Financial Studies*, 30(1), pp.2-47.
- Agyei-Ampomah, S. (2011): "Stock Market Integration in Africa" *Managerial Finance*, 37(3), pp.242-256.
- Aizenman, J., Jinjark, Y., Lee, M. and Park, D. (2016): "Developing countries' financial vulnerability to the eurozone crisis: an event study of equity and bond markets" *Journal of Economic Policy Reform*, 19(1), pp.1-19.
- Alagidede, P. (2011): "Return Behaviour in Africa's Emerging Equity Markets" *The Quarterly Review of Economics and Finance*, 51(2), pp.133-140.
- Allen, F. and Giovannetti, G. (2011): "The effects of the financial crisis on Sub-Saharan Africa" *Review of Development Finance*, 1(1), pp.1-27.
- Asongu, S. A. (2011): "Political Crises and Risk of Financial Contagion in Developing Countries: Evidence from Africa" *Journal of Economics and International Finance*, 3(7), pp. 462-467.
- Bello, J. and Rodgers, T. (2016): "Financial Contagion from US to African Frontier Markets during the 2007-2009 Global Financial Crisis", in *Handbook of Frontier Markets Vol.1: The African, European and Asian Evidence*, eds. P. Andrikopoulos, G. N. Gregoriou, and V. Kallinterakis Amsterdam: Academic Press, pp.93-114.
- Bello, J. (2014): "The 2007-09 Global Financial Crisis and Financial Contagion Effects in African Stock Markets", Unpublished PhD Thesis, Coventry University, United Kingdom.
- Bollerslev, T. A. (1987): "Conditionally Heteroskedastic Time Series Model for Speculative Prices and Rates of Return" *The Review of Economics and Statistics*, 69(3), pp.542-547.
- Burnham, K. P. and Anderson, D. R. (2004): "Multimodel inference understanding AIC and BIC in model selection" *Sociological Methods & Research*, 33(2), pp.261-304.
- Cappiello, L., Engle, R. F. and Sheppard, K. (2006): "Asymmetric dynamics in the correlations of global equity and bond returns" *Journal of Financial Econometrics*, 4(4), pp.537-572.
- Carhart, M. M. (1995): "Survivor bias and persistence in mutual fund performance", PhD Thesis, The University of Chicago, United States.
- Carhart, M. M. (1997): "On Persistence in Mutual Fund Performance" *Journal of Finance*, 52(1), pp.57-82.
- Cavanaugh, J. E. and Neath, A. A. (1999): "Generalizing the derivation of the Schwarz

- information criterion” *Communications in Statistics-Theory and Methods*, 28(1), pp.49-66.
- Chevapatrakul, T. and Tee, K. (2014) “The Effects of News Events on Market Contagion: Evidence from the 2007–2009 Financial Crisis”. *Research in International Business and Finance* 32, 83-105
- Chiao, C., Hung, K. and Srivastava, S. C. (2003): “Taiwan Stock Market and Four-Moment Asset Pricing Model” *Journal of International Financial Markets, Institutions and Money*, 13(4), pp.355-381.
- Collins, D. and Biekpe, N. (2003): “Contagion and Interdependence in African Stock Markets” *The South African Journal of Economics*, 71(1), pp.181-194.
- Engle, R. (2002): “Dynamic Conditional Correlation: A Simple Class of Multivariate Generalized Autoregressive Conditional Heteroskedasticity Models” *Journal of Business & Economic Statistics*, 20(3), pp.339-350.
- Essers, D. (2013). “Developing country vulnerability in light of the global financial crisis: Shock therapy?” *Review of Development Finance*, 3(2), pp.61-83.
- Fama, E. F. and French, K. R. (1992): “The Cross-Section of Expected Stock Returns” *Journal of Finance*, 47(2), pp.427-465.
- Forbes, K. and Rigobon, R. (2002): “No contagion, only interdependence: measuring stock market co-movements” *Journal of Finance*, 57(5), pp.2223–2261.
- FTSE (2014): “FTSE quality of market criteria (AFRICA)” Available online: http://www.ftse.com/products/downloads/FTSE_Country_Classification_Paper.pdf (Accessed on 11th September 2014)
- Giovannetti, G., and Velucchi, M. (2013): “A spillover analysis of shocks from US, UK and China on African financial markets” *Review of Development Finance*, 3(4), pp.169-179.
- Glosten, L. R., Jagannathan, R. and Runkle, D. E. (1993): “On the relation between the expected value and the volatility of the nominal excess return on stocks” *The Journal of Finance*, 48(5), pp.1779-1801.
- Hearn, B. (2011): “Modelling Size and Liquidity in North African Industrial Sectors” *Emerging Markets Review*, 12(1), pp.21-46.
- Hearn, B. and Piesse, J. (2009): “Sector Level Cost of Equity in African Financial Markets” *Emerging Markets Review*, 10(4), pp.257-278.
- Hwang, S., and Satchell, S. E. (1999): “Modelling Emerging Market Risk Premia Using Higher Moments” *International Journal of Finance and Economics*, 4, pp.271-296.

- Jain, P. (2002): "Institutional Design and Liquidity at Stock Exchanges around the World", Working Paper, SSRN.
- Jin, X. and An, X. (2016) "Global Financial Crisis and Emerging Stock Market Contagion: A Volatility Impulse Response Function Approach". *Research in International Business and Finance* 36, 179-195
- King, M., and Wadhwani S. (1990): "Transmission of Volatility between Stock Markets" *Review of Financial Studies*, 3(1), pp.5-33.
- Lesmond, D. A. (2005): "Liquidity of Emerging Markets" *Journal of Financial Economics*, 77(2), pp.411-452.
- Lintner, J (1965): "The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets". *The Review of Economics and Statistics*, 47(1), pp.13-37.
- Ljung, G. M. and Box, G. E. (1978): "On a measure of lack of fit in time series models" *Biometrika*, 65(2), pp.297-303.
- Mayer, N. (2013): "Top performing sectors of the JSE" Available online: http://www.sharenet.co.za/marketviews/article/Top_Performing_Sectors_of_the_JSE/1877 (Accessed on 7th September 2014)
- Merton, R. C. (1973): "An Intertemporal Capital Asset Pricing Model" *Econometrica*, 41(5), pp.867-887.
- Moore, T. and Wang, P. (2014): "Dynamic linkage between real exchange rates and stock prices: Evidence from developed and emerging Asian markets" *International Review of Economics and Finance*, 29, pp.1-11.
- Omran, M. F. (2007): "An Analysis of the Capital Asset Pricing Model in the Egyptian Stock Market" *The Quarterly Review of Economics and Finance*, 46(5), pp.801-812.
- Pástor, L., and Stambaugh, R. F. (2003): "Liquidity risk and expected stock returns" *Journal of Political Economy*, 111(3), pp.642-685.
- Sharpe, W. F. (1964): "Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk" *Journal of Finance*, 19(3), pp.425-442.
- Shibata, R. (1976): "Selection of the order of an autoregressive model by Akaike's information criterion" *Biometrika*, 63(1), pp.117-126.
- White, H. (1980): "A heteroscedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity" *Econometrica*, 48(4), pp.817-838.
- Wooldridge, J. M. (2009): *Introductory Econometrics: A Modern Approach*. Australia: South-Western Cengage Learning.

APPENDIX

Table A.1: DCC(1,1)-GJRGARCH(1,1) and DCC(1,1)-GARCH(1,1) Models for the Estimation of Time-Varying Beta in African Emerging Markets

Mean Equations	Parameter	Emerging Africa		Emerging Africa Excluding South Africa		South Africa	
		r_{it}	r_{jt}	r_{it}	r_{jt}	r_{it}	r_{jt}
	α	-0.380***	-0.185***	-0.399**	-0.312**	-0.065	-0.070**
	SMB	0.072	-0.033	-0.266***	-0.102**	-	-
	HML	-0.084	-0.003	0.112**	0.071**	0.003	-0.021
	UMD	0.062***	0.042***	0.391***	0.336***	0.069	0.034
	IMV	-0.154	-0.147	0.027	-0.073	-	-0.122**
	Skewness	0.0003	0.0004	-0.001	-0.004*	-0.001	-0.001
	Kurtosis	0.385***	0.190***	0.401**	0.317**	0.069	0.075**

	Parameter	Emerging Africa	Emerging Africa Excluding South Africa	South Africa
Variance: portfolio	Model Specification	GJR-GARCH(1,1)	GARCH(1,1)	GJR-GARCH(1,1)
	ω	0.849*	1.095**	0.882*
	ARCH (α)	0.058	0.252***	0.077
	GARCH (β)	0.667***	0.529***	0.783***
	GJR (γ)	0.001*		0.065
Variance: Market	Model Specification	GJR-GARCH(1,1)	GARCH(1,1)	GJR-GARCH(1, 1)
	ω	0.446*	0.518*	0.660***
	ARCH (α)	-0.017	0.166**	-0.040
	GARCH (β)	0.723***	0.727***	0.718***
	GJR (γ)	0.261*		0.299***
DCC	ρ	0.551***	0.546***	0.509***
	η	0.029	0.095	0.023
	θ	0.909***	0.718**	0.907***
	df	8.185***	5.856***	11.157***

*Significant at 10%, **Significant at 5%, ***Significant at 1%. Estimation based on 574 observations and uses Oxmetrics 7 as the estimation package. Diagnostic tests were undertaken. The Q-Statistic (Ljung and Box, 1978) for the standardised residuals is used to test for autocorrelation in the mean equation (undertaken with lags 1 and 5). Rejection of the null indicates the presence of miss-specification errors. The Q-Statistic test on the squared standardised residuals was used to examine for the presence of ARCH effects in the variance equation (undertaken with lags 1, 5 and 10). No evidence of autocorrelation was found.